Defining a Target Fish Community for Planning and Evaluating Enhancement of the Quinebaug River in Massachusetts and Connecticut

By

Mark B. Bain and Marcia S. Meixler

New York Cooperative Fish and Wildlife Research Unit
Fernow Hall - Cornell University
Ithaca, New York 14853-3001

With the Data and Guidance of

Todd Richards, Massachusetts Division of Fisheries and Wildlife
Richard A. Jacobson, Connecticut Department of Environmental Protection
Robert J. Maietta, Massachusetts Department of Environmental Protection

For

Quinebaug River Instream Flow Study Agencies

New England Interstate Water Pollution Control Commission
Connecticut Department of Environmental Protection
Massachusetts Department of Environmental Protection
Massachusetts Division of Fisheries and Wildlife
U. S. Generating Company
U. S. Army Corps of Engineers
U. S. Environmental Protection Agency
U. S. Fish and Wildlife Service

17 July 2000

INTRODUCTION

Efforts to enhance the Quinebaug River for the support of healthy aquatic communities should be guided by clear objectives and be open to objective evaluation. This report covers our effort to develop a model fish community to serve as a target for river enhancements and an endpoint for evaluating program progress. The US Clean Water Act calls for efforts to "restore and maintain the physical, chemical, and biological integrity of the Nation's waters". Biological integrity has been defined (Karr 1991) as the ability to support and maintain "a balanced, integrated, adaptive community of organisms having a species composition, diversity, and functional organization comparable to that of natural habitat of the region". Thus we propose and demonstrate a method to define a community of fish that is appropriate for a natural river in southern New England by specifying common members, the balance of abundances, species organization, and biological attributes. Our target community is combined with a similarity measurement method to assess the extent that a sampled community is comparable to that of a natural habitat.

Striving for natural habitats and communities may not be practical in settled areas, and a focus on solely natural environmental characters may not yield feasible enhancement actions. Thus we demonstrate an inference approach to summarize the ways that a current community differs from target conditions. That is, we use the target community as a benchmark for assessing comparability and also to identify the nature of departures. For example, exotic fish make up a substantial (ca. 25%) portion of the fish in southern New England, and many of them are valued species with naturalized populations. Departures from a target community may be a result of introduced species, and their influence would compromise a natural community. However, by characterizing deviations from natural conditions the investigator can incorporate other interests in conclusions about current conditions. Finally, some of the methods presented here are new, and we can make adjustments and changes in the method as our shared experiences dictate.

METHODS

A comprehensive list of fish species known to have inhabited the Thames River basin was obtained from Schmidt (1986). He reported 57 species present including 14 species introduced many decades ago such as largemouth and smallmouth bass, walleye, and northern pike. Whitworth's (1996) "Freshwater Fishes of Connecticut" was then reviewed which raised the total list of potential species to 64. From this list, species were deleted for a variety of reasons (Table 1): ten marine and estuarine species only enter coastal freshwater habitats; four species have a restricted distribution to estuarine and coastal areas in the New England region but are more prevalent in other United States regions (Whitworth 1996); five species migrations and habitats are mainly limited to the Atlantic coastal plain; two species were judged out of range by detailed distribution information in Whitworth (1996); and four were historically introduced species that failed to become established. Four anadromous species have been blocked for over a century from reaching the Quinebaug River by several dams. These fish are not included in the community analyses, but were retained for final interpretation of community alterations. Finally, some species (white catfish, swamp darter) were added because of recent occurrence records.

Quality rivers in the same major river basin (Thames River) as the Quinebaug River or similar southern New England coastal basins were used to guide the specification of a target fish fauna. The reference rivers were those recommended by fish biologists of the Massachusetts Division of Fisheries and Wildlife and the Connecticut Department of Environmental Protection as examples of rivers in desirable condition. The reference rivers were not considered to be in a fully natural or a pristine state as such rivers are not available. Thus, these reference rivers provide the best data for characterizing the natural fauna of the Quinebaug River. The rivers chosen and the years of the fish sampling data were: the Ware (1980, 1992) and Housatonic (1999) Rivers in Massachusetts, and the Fivemile (1994), Natchaug (1994), Scantic (1989), and Willimantic (1994) Rivers in Connecticut.

Using the reference river data, a description of a target fish community for the Quinebaug River was produced with some simple spreadsheet calculations. First, the numbers of fish were tallied by species for all collections available from each of the reference rivers. Then, for each river the species tallies were divided by the total number of individuals captured to obtain the proportion of total individuals by species. Stocked species (rainbow and brown trout) were removed from the analysis since these only inhabit the rivers at the stocking size and this provides no useful information on the wild fish community. Proportions of each species were summed across the six reference rivers, and the summed proportions were ranked (1 being the most common dominant species, 2 the next most common dominant, and so on). At this point, all non-native fishes were excluded by eliminating their ranks. The remaining species ranks were then converted to expected proportions used to estimate species abundances in a model or target community. Expected proportions were computed by converting species ranks to reciprocals (1/rank), summing these in decimal form, and dividing reciprocal rank (decimal) by the sum of all reciprocal ranks. This procedure assumes that the expected proportions of the fish community assigned to each species is approximated by their average rank across the set of reference rivers. Uncommon species (less common that the 10th ranked native fish) were grouped into "other", and the expected proportion of this group was the sum of their expected proportions.

Our target fish community, defined by species proportions, was compared to the species composition of recent fish collections (nine sites, Figure 1) along the Quinebaug River provided by the Massachusetts Division of Fisheries and Wildlife (eight sites, 1999) and the Connecticut Department of Environmental Protection (one site, 1994). The comparisons of target and current fish communities were made using a percent model affinity procedure (Novak and Bode 1992). The percent model affinity method yields values on a scale from 0 to 100 which describe the extent that a fish collection at a site on the Quinebaug River matched our target community. High affinity values correspond to higher levels of correspondence with the target community. The percent model affinity method uses a percent similarity measure (Novak and Bode 1992) computed as:

$$\text{Percent similarity} = 100 - 0.5\,(\text{sum } |\text{target P} - \text{observed P}|)$$

where: P = proportions of each species in the community or collection.

The observed proportions of the top 10 target fishes were used to identify the Quinebaug River fish species occurring at expected abundances, under represented, or overly abundant. The species expected in the river that were not recorded were also identified. Interpreting the significance of the deviations from a target community was done by reviewing the habitat requirements and pollution tolerances for species in the observed abundance groups.

Species habitat requirements and pollution tolerances were reviewed (Appendix A) and classified using regional and state ichthyology books (Scott and Crossman 1973, Pflieger 1975, Lee et al. 1980, Trautman 1981, Becker 1983, Burr and Warren 1986, Robison and Buchanan 1988, Jenkins and Burkhead 1994). As a group, these reference books describe the North American life history of fish. Habitat requirements were summarized into three macrohabitat (water body type) classes: generalists (MG), fluvial dependents (FD), and fluvial specialists (FS). The species life history notes (North American scale) and habitat need classifications are reported in Appendix B for all known and potential (current) inhabitants of the Quinebaug River basin. To accommodate regional differences in habitat requirements, three of the habitat classifications (fallfish, longnose dace, and brook trout) were changed from habitat generalists to fluvial specialists (regional) by agreement of this project's fishery agency advisors. American eel is a catadromous fish (migrates to sea for spwaning) that requires access to stream habitats to complete its life cycle. This fish was reclassified as a fluvial dependent for this reason even though the species occupies a wide range of habitats throughout life. We used the pollution tolerance classification of Halliwell et al. (1999) for Northeast US fishes: intolerant (I), moderately tolerant (M), or tolerant (T). Finally, species were designated as native or exotic (introduced) from Schmidt (1986) and Whitworth (1996).

RESULTS

Our review of the potential and known fishes of the Quinebaug River basin resulted in a list (Appendix B) of 36 species we would expect to be found in streams, lakes, and river reaches of the basin. The species list contains native and introduced fishes, and a full range of sensitivities to habitat and water quality degradation. Many of these fish have not been recorded in recent sampling, but they are considered candidate species for collection in any survey. In addition to the 36 expected species in the basin, there are four anadromous fish that could be restored to the fauna by actions outside the study area. These anadromous fish are: blueback herring (*Alosa aestivalis*), American shad (*Alosa sapidissima*), Sea lamprey (*Petromyzon marinus*), and Atlantic salmon (*Salmo salar*).

The fish composition data for the six reference rivers (Table 2) provided the guidance for specifying the rank order of species in our target community. Fallfish were a clear dominant fish in two of six rivers, and abundant in three other rivers. Common shiner was a dominant species in two rivers and abundant in another river. These two fishes were ranked first and second respectively, with other high ranked (low rank number) fishes common in most of the reference rivers. Following these results, the rank order of species in our target community for the Quinebaug River is: fallfish, common shiner, white sucker, longnose dace, eastern blacknose dace, tessellated darter, redbreast sunfish, American eel, yellow perch, and pumkinseed. We expect then that a high quality fish community in the Quinebaug River would display approximately this order of abundance by species (fish over ca. 25 mm total length). When converted to expected abundance proportions, the target fish community for the Quinebaug River would be comprised of fallfish (31%), common shiner (15%), white sucker (10%), longnose dace (8%), eastern blacknose dace (6%), tessellated darter (5%), redbreast sunfish (3%), american eel (3%), yellow perch (3%), pumpkinseed (2%), and other (14%, Figure 2).

Using the recent Quinebaug River survey data, a set of comparisons were made between the target fish community and the observed fish communities at the 9 sites plotted on Figure 1. Similarity among target and observed communities was summarized with the percent affinity measure (Table 3). The Quinebaug River sites varied in the extent that fish collections conformed to target conditions. In general, the species expected to be dominant were often abundant, but at levels below target proportions. Also, several fishes expected to be at low abundances (members of the Other class) were sometimes found in high abundances. Affinity index values ranged from a 65% match with target conditions to a 35% match. The spatial variation in these affinity index values (Figure 3) indicated moderate values at the upstream end of the study reach with a slight but steady increase downstream through the high gradient stream sites in the City of Southbridge. The model affinity value for site 53 was unusally low. This site was at the downstream edge of Southbridge where municipal sewage treatment plant and possibly other discharges occur. Further downstream (Site 72), an affinity value similar to upstream sites was obtained, and then just inside the State of Connecticut another low value was recorded.

The affinity values can be explained by comparing species composition values with model community proportions (Table 3). Furthermore, information on species ecology can be combined with the deviations in species abundances (Table 4) to infer the status of the Quinebaug River fish community and environment. The species found at abundances less than expected for a target fish community were largely specialists on flowing water habitats or dependents on streams for part of their life cycle. Fish found at abundances equal to or greater than expected were almost all habitat generalists. Species not recorded included a mix of generalists and fluvial specialists. Pollution tolerances did not appear to vary by abundance group except for the species not found at any site. The missing fishes included five pollution intolerant species, and these sensitive fishes comprised half of the missing fishes. Finally, the four anadromous fishes were indeitified as missing (Table 4) because they would be an important part of the expected fish community if there were no obstacles to migration downstream of the Quinebaug River.

DISCUSSION

This analysis and report provides the first clear look at the present fish community of the Quinebaug River. The recent survey data indicate a river fish fauna that differs from the target community, but it is not a largely foreign assemblage of fish. The common fishes of the river included those expected for natural rivers in the region, and some now abundant introduced species. However, many abundant fishes were predicted by model community composition to be found in relatively low numbers, and these overly abundant fishes tend to be habitat generalists and tolerant of altered water quality. Thus the mix of species appears changed by prevailing river conditions and species introductions, and evidence for both habitat and water quality degradation was seen in the summary of species by abundance group.

The results of change in target community affinity along the river was also informative of the prevailing pattern of river quality. Affinity values were very similar at most sites along the Quinebaug River indicating a moderate correspondence with target conditions. These summary values were obtained across sites with clear variation in species composition but a general abundance of the anticipated stream fishes. Nevertheless, two sites (53, 20) had poor values indicating a sharp departure from target conditions. The fish community at site 53 was dominated by redbreast sunfish and smallmouth bass; species that should be minor community components. This site is easily recognized as a heavily degraded stream location due to pollutant discharges, channelization, bank stabilization, extensive adjacent human infrastructure, and adjacent downstream impoundment. At site 20, spottail shiners were a clear dominant species accounting for more than half of the fish recorded, and common shiner were also overly abundant. This site is not readily identifiable as degraded but is an area recently inundated by a now failed dam. Additional year 2000 fish surveys will likely help clarify the value of our restoration target setting approach and analysis techniques. However, this first application appears to have yielded reasonable results that are helpful in pursuing project goals.

The process of specifying a target fish community revealed how challenging it is to judge what constitutes a natural river fish community. Developing a list of species in the river basin was relatively clear and straightforward with a few notable exceptions. The main starting material (Schmidt 1986, Whitworth 1996) readily yielded a grand list of species expected to be inhabiting the river and associated waters or potentially occurring in the basin. Most refinements to this list could be easily made by a biologist familiar with the regional fauna. However, the inclusion of a few species (e.g., fathead minnow, redfin pickerel, slimy scuplin) was difficult to resolve because experienced regional fish biologists had conflicting accounts of the local distribution of these fish. Handling of anadromous fishes was also complicated by different views on long-term management actions. We included anadromous fishes in the final summary table (Table 4) but we did not include them in the target community specification. Little is known about the extent and abundance of anadromous fish in far inland waters like the Quinebaug River because dams blocking migrations were widely established in the 1800s. Future restoration of anadromous fish to the Quinebaug River depends on actions taken outside the study area. Hence, anadromous fish are not a community component in the context of the current river restoration planning, but they could be an important part of restoration planned within a large scope. Overall, target community composition predictions are straightforward for a potential species list with the exception of adjustments for very recent and far future information.

There was substantial variation in community composition among the six reference rivers recommended as quality rivers for the region. Common species varied considerably in their relative abundance by river, and normally uncommon species were sometimes abundant. Therefore, it would likely be impossible to specify precisely what the fish community should be like for the Quinebaug River or others in the region. To reach a generalized target community, we lessened the influence of reference river survey data by using mean rank abundances to define target community composition. Also, the use of six reference rivers helped to moderate the influence of any one river in defining a target community.

Our target fish community can be used as a general guide of what is considered a healthy fish community for large streams and small rivers in the region. By adopting it as a standard, we could also use the target community to numerically rate the similarity of any fish collection or study site to target conditions. Finally, computing affinity index values for specific collections and sites allows comparisons to be made of target similarity across sites and times. We conducted these analyses as a demonstration exercise with the Massachusetts Division of Fish and Wildlife and Connecticut Department of Environmental Protection fish collections along the Quinebaug River. The results of that exercise show what can be done with a specified target fish community for planning and assessment. However, we believe that additional application trials need to be done to have confidence in these analyses. Additional applications are underway now with other rivers and regions where good data exist for judging the significance of river impacts. Aside from building confidence, additional application experience is needed to fully interpret affinity index values. The percent model affinity method employed here copies much of the approach from the method's original authors (Novak and Bode 1992). In their benthic bioassessment analyses using the percent model affinity, Novak and Bode provide index ranges corresponding with severely impacted, moderately impacted, slightly impacted, and non-impacted. These index ranges were chosen from extensive field experience using the method. As we experiment with further applications of our fish-based affinity method, we will be able to propose index ranges for similar interpretations of aquatic system quality. For now though, the target fish community specified here serves immediate project needs and the method may prove more useful for general application in the near future.

REFERENCES

Becker, G. C. 1983. Fishes of Wisconsin. The University of Wisconsin Press, Madison, Wisconsin.

Burr, B. M. and M. L. Warren, Jr. 1986. A distributional atlas of Kentucky fishes. Kentucky Nature Preserves Commission, Scientific and Technical Series Number 4, Carbondale, Illinois.

Halliwell, D. B., R. W. Langdon, R. A. Daniels, J. P. Kurtenbach, and R. A. Jacobson. 1999. Classification of freshwater fish species of the northeastern United States for use in the development of indices of biological integrity, with regional applications. Pages 301-333 *in* T. P. Simon, editor. Assessing the sustainability and biological integrity of water resources using fish communities. CRC Press, Boca Raton, Florida.

Jenkins, R. E. and N. M. Burkhead. 1994. Freshwater fishes of Virginia. American Fisheries Society, Bethesda, Maryland.

Karr, J. R. 1991. Biological integrity: a long-neglected aspect of water resource management. Ecological Applications 1:66-84.

Lee, D. S., C. R. Gilbert, C. H. Hocutt, R. E. Jenkins, D. E. McAllister, J. R. Stauffer, Jr. 1980. Atlas of North American freshwater fishes. North Carolina State Museum of Natural History.

Novak, M.A. and R.W. Bode. 1992. Percent model affinity: a new measure of macroinvertebrate community composition. Journal of the North American Benthological Society 11(1):80-85

Pflieger, W. L. 1975. The fishes of Missouri. Missouri Department of Conservation, Springfield, Missouri.

Robison, H. W. and T. M. Buchanan. 1988. Fishes of Arkansas. The University of Arkansas Press, Fayetteville, Arkansas.

Schmidt, R. E. 1986. Zoogeography of the northern Appalachians. Pages 137-159 *in* C. H. Hocutt and E. O. Wiley, editors. The Zoogeography of North American Freshwater Fishes. John Wiley & Sons, New York, New York.

Scott, W. B. and E. J. Crossman. 1973. Freshwater fishes of Canada. Bulletin 184. Fisheries Research Board of Canada, Ottawa.

Trautman, M. B. 1981. The fishes of Ohio. Ohio State University Press, Columbus, Ohio.

Whitworth, W. R. 1996. Freshwater fishes of Connecticut. Bulletin 114. State Geological and Natural History Survey of Connecticut, Hartford, CT.

Table 1. Species deleted from a comprehensive list of Quinebaug River fish and reasons for deletion.

Scientific Name	Common Name	Reason for deletion [¥]
Anchoa mitchilli	Bay anchovy	ME
Alosa pseudoharengus	Alewife	ME
Microgadus tomcod	Atlantic tomcod	ME
Cyprinodon variegatus	Sheepshead minnow	ME
Fundulus heteroclitus	Mummichog	ME
Lucania parva	Rainwater killifish	ME
Menidia beryllina	Inland silverside	ME
Menidia menidia	Atlantic silverside	ME
Gobiosoma bosci	Naked goby	ME
Trinectes maculatus	Hogchoker	ME
Apeltes quadracus	Fourspine stickleback	EC
Gasterosteus aculeatus	Threespine stickleback	EC
Pungitius pungitius	Ninespine stickleback	EC
Morone saxitilis	Striped bass	EC
Osmerus mordax	Rainbow smelt	M
Alosa mediocris	Hickory shad	M
Dorosoma cepedianum	Gizzard shad	M
Aphredoderus sayanus	Pirate perch	M
Enneacanthus obesus	Banded sunfish	M
Percopsis omiscomaycus	Trout-perch	R
Etheostoma fusiforme	Swamp darter	R
Lepomis cyanellus	Green sunfish	Ix
Stizostedion vitreum	Walleye	Ix
Pomoxis annularis	White crappie	Ix
Salvelinus namaycush	Lake trout	Ix

¥ ME = marine and estuarine species which only enter coastal freshwater habitats; EC = species with a restricted distribution to estuarine and coastal areas in the New England region but are more prevalent in other United States regions; M = species migrations and habitats are mainly limited to the Atlantic coastal plain; R = judged out of range by detailed distribution information; Ix = Introduced in the past with no evidence of being established in the basin.

Table 2. Fish species in reference river collections with their mean rank and expected contribution to the Quinebaug River community. Introduced species were deleted from the expected proportion values (dash entries) and the composition of the target community.

Species name	Ware River	Housa-tonic River	Willi-mantic River	Natchaug River	Fivemile River	Scantic River	Mean rank	Expected Pro-portion [*f*]
American Eel			21	24	18	239	10	0.03
Brook Trout						12	20	0.01
Northern Pike				1			27	-
Chain Pickerel	8		7	9	29		16	0.02
Goldfish			3			21	18	-
Common Shiner	25		1440	19	691	342	2	0.15
Golden Shiner	1	1	22		26	11	17	0.02
Spottail Shiner	6		16			1	19	0.02
E Blacknose Dace	5	87	557	13	119	138	5	0.06
Longnose Dace	70	93		6	229	231	4	0.08
Creek Chub		14					15	0.02
Fallfish	226	1	3194	262	175	189	1	0.31
Common Carp		2					22	-
White Sucker	179	43	1092	91	70	131	3	0.10
Creek Chubsucker					1		28	0.01
Yellow Bullhead	2				8		23	-
Brown Bullhead			2	1	7	1	24	0.01
Rock Bass	11	7	10	15		11	14	-
Redbreast Sunfish			150	89	93	24	9	0.03
Green Sunfish			6	1			26	-
Pumpkinseed	36	1	50	22	17	7	13	0.02
Bluegill	6	1	12	91	147	33	7	-
Smallmouth Bass			226	78		1	11	-
Largemouth Bass	116	5	23	7	121	3	8	-
Black Crappie	3					3	25	-
Tesselated Darter	259		104	58	17	125	6	0.05
Yellow Perch	32	2	193	4	37	3	12	0.03
Sea Lamprey						12	20	0.01

f Expected proportion for species below the 10 most common were pooled into Other and that class is expected to compose 14% of the community.

Table 3. Comparison of recent fish collections at nine sites along the Quinebaug River (see Figure 1) and the model fish community (model %). The observed percent composition values are reported with the corresponding site affinity index value.

Fish species	Model %	Percent composition by site								
		50	51	73	54	55	52	53	72	20
Fallfish	31	45	21	28	16	16	31	14	23	7
Common Shiner	15	1	57	5	25	43	14	1	5	21
White Sucker	10	6	8	8	1	10	1	<1	22	6
Longnose Dace	8		8		10	5				1
Blacknose Dace	6		3		1	1				
Tesselated Darter	5	1				2		1		
Redbreast Sunfish	3	8	2	14	19	8	15	30	7	1
American Eel	3					1				
Yellow Perch	3			18	1				9	<1
Pumpkinseed	2	1		16	2		<1	6	3	<1
Other	14	38	1	11	26	16	38	49	32	64
Smallmouth Bass		1		1	10	1	33	34	18	3
Spottail Shiner						13				57
Yellow Bullhead		15	<1	4	10	1	4	8	4	2
Bluegill		13		1	6	<1	<1	2	2	2
Largemouth Bass		8	1	1			1	3	6	<1
Golden Shiner				3					2	
Chain Pickerel		1						1		
Brown Bullhead								1		
Black Crappie		1								
% Model Affinity		57	58	59	60	65	63	35	60	44

Table 4. Review of species relative to target community abundances, source, habitat requirements, and pollution tolerances.

Species	Source	Habitat requirements	Pollution tolerance	Comments
Underrepresented species				
Fallfish	Native	Fluvial specialist	Moderate	Generally below expectations
White Sucker	Native	Fluvial dependent	Tolerant	Sparce numbers at some sites
Longnose Dace	Native	Fluvial specialist	Moderate	Absent at many sites
Blacknose Dace	Native	Fluvial specialist	Tolerant	Absent at many sites
Tesselated Darter	Native	Fluvial specialist	Moderate	Absent at many sites
American Eel	Native	Fluvial dependent	Tolerant	Almost always absent
Species recorded as expected				
Yellow Perch	Exotic	Generalist	Moderate	Occasionally numerous
Golden Shiner	Native	Generalist	Tolerant	Few captures in low numbers
Chain Pickerel	Native	Generalist	Moderate	Few captures in low numbers
Brown Bullhead	Native	Generalist	Tolerant	Few captures in low numbers
Black Crappie	Exotic	Generalist	Moderate	Few captures in low numbers
Overly abundant species				
Common Shiner	Native	Fluvial dependent	Moderate	Dominant fish at some sites
Redbreast Sunfish	Native	Generalist	Moderate	Overly abundant at most sites
Pumpkinseed	Native	Generalist	Moderate	Highly abundant at some sites
Smallmouth Bass	Exotic	Generalist	Moderate	Highly abundant at some sites
Spottail Shiner	Native	Generalist	Moderate	Highly abundant at some sites
Yellow Bullhead	Exotic	Generalist	Tolerant	Highly abundant at some sites
Bluegill	Exotic	Generalist	Tolerant	Abundant at some sites
Largemouth Bass	Exotic	Generalist	Moderate	Abundant at some sites
Missing native species				
Brook Trout		Fluvial specialist	Intolerant	
Redfin Pickerel		Generalist	Moderate	
Bridle Shiner		Generalist	Intolerant	
Fathead Minnow		Generalist	Tolerant	
Creek Chub		Generalist	Tolerant	
Creek Chubsucker		Fluvial specialist	Intolerant	
Banded Killifish		Generalist	Tolerant	
White Perch		Generalist	Moderate	
Swamp Darter		Generalist	Intolerant	
Slimy Sculpin		Fluvial specialist	Intolerant	
Blueback herring		Anadromous		
American shad		Anadromous		
Sea lamprey		Anadromous		
Atlantic salmon		Anadromous		

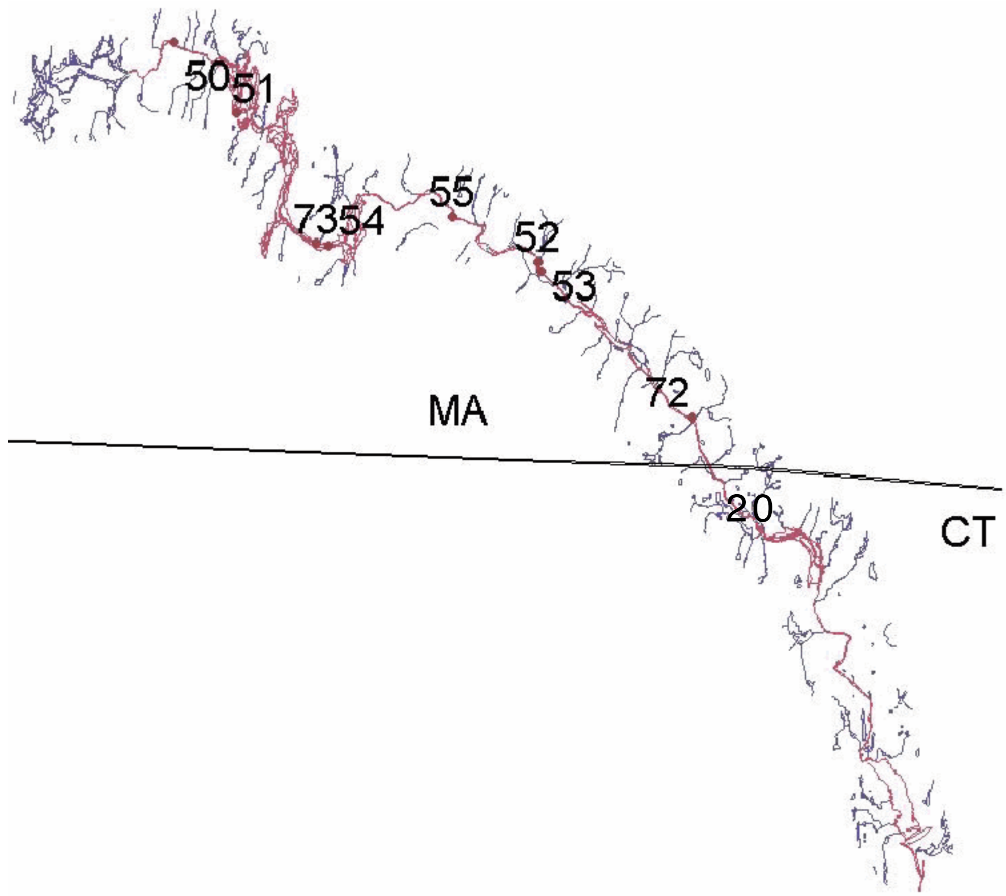

Figure 1. Locations of the Masschusetts Division of Fish and Wildlife 1999 stream sampling sites: Fiskdale (50), Old Sturbridge village (51), Westville Dam area (73), Westville Dam (54), Southbridge Rt. 131 (55), Southbridge at Big Y Store (52), Southbridge at school bus lot (53), and Dudley (72). Route 197 near the town of Quinebaug (20) was sampled by the Connecticut Department of Environmental Protection in 1994.

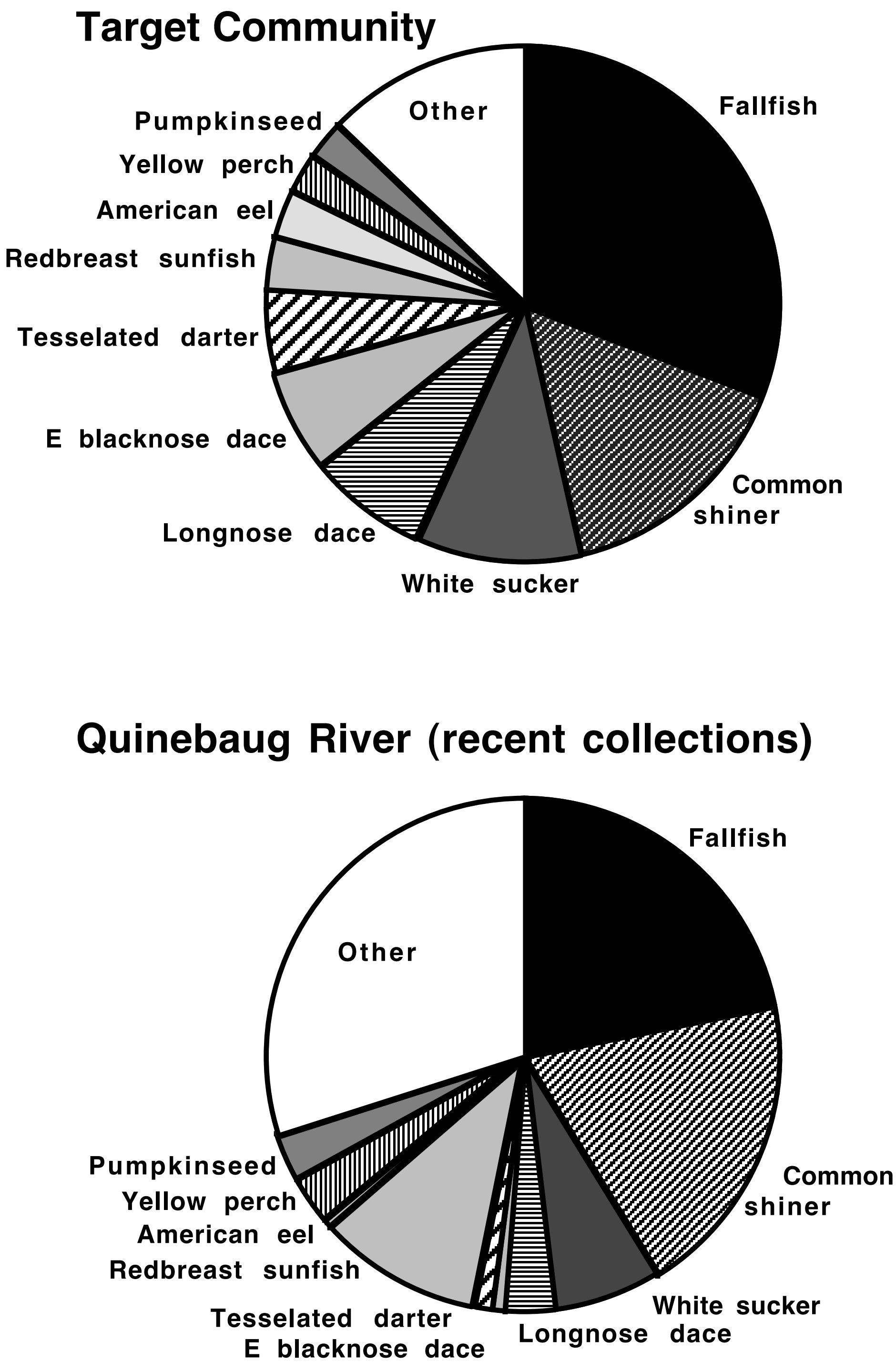

Figure 2. Species composition of target community and the pooled Quinebaug River survey samples of the Massachusetts Division of Fisheries and Wildlife in 1999 and the Connecticut Department of Environmental Protection in 1994.

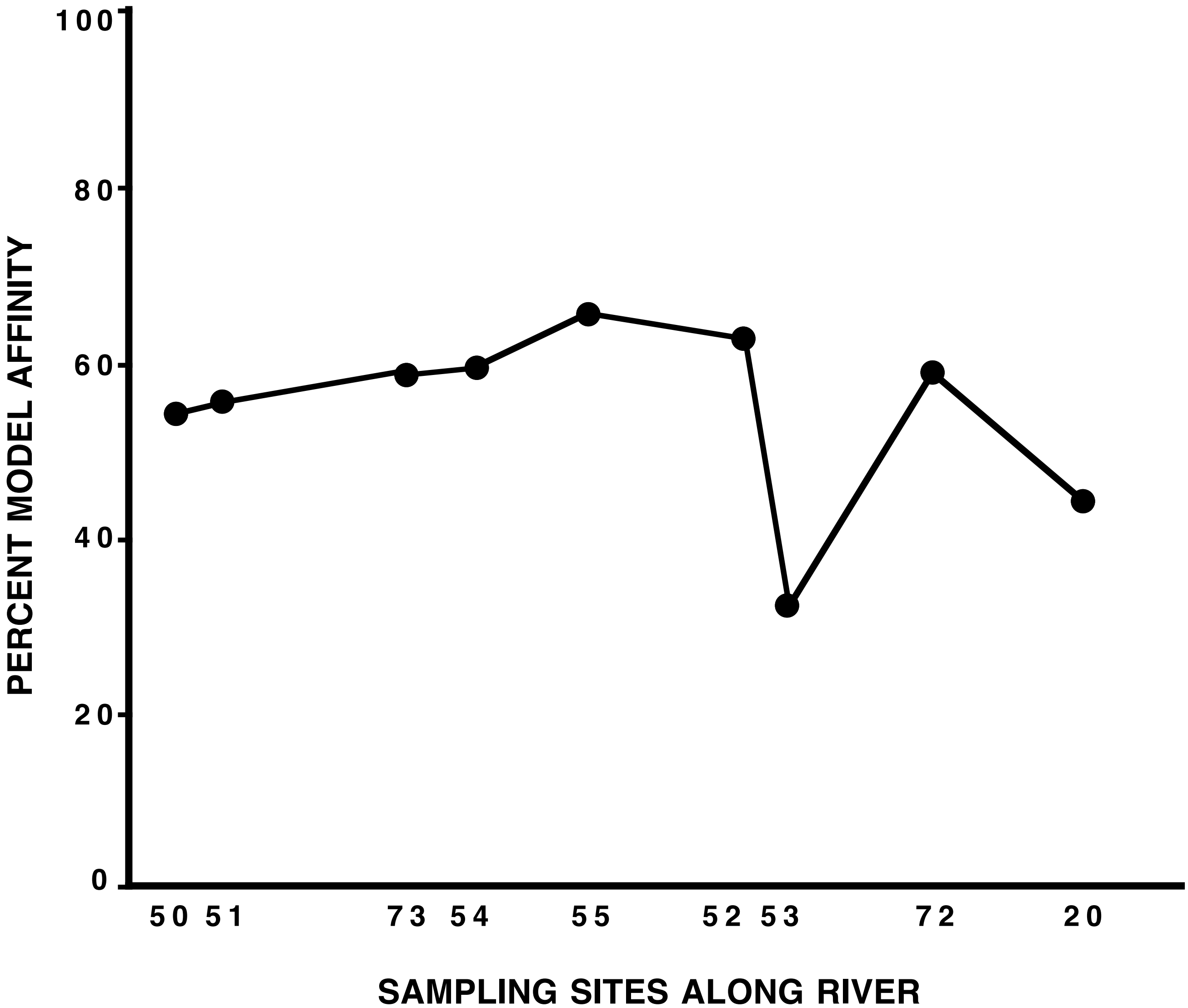

Figure 3. Downstream trend in correspondence of site samples with the target fish community where affinity values of 100 equals a perfect match and zero indicates no similarity. Community affinity values correspond with the sampling sites shown in Figure 1.

APPENDIX A

Review of Life History Information on the
Expected Fishes of the Quinebaug River Basin

Not included in this copy

APPENDIX B

Expected Fishes of the Quinebaug River Basin

Common name	Genus	Species	Introduced or Native	Habitat Use Classification	Pollution tolerance
Anguillidae					
American eel	Anguilla	rostrata	N	FD	T
Salmonidae					
Rainbow trout	Oncorhynchus	mykiss	I	FD	I
Brown trout	Salmo	trutta	I	FD	I
Brook trout	Salvelinus	fontinalis	N	FS	I
Esocidae					
Redfin pickerel	Esox	americanus	N	MG	M
Northern pike	Esox	lucius	I	MG	I
Chain pickerel	Esox	niger	N	MG	M
Cyprinidae					
Goldfish	Carassius	auratus	I	MG	T
Common shiner	Luxilus	cornutus	N	FD	M
Golden shiner	Notemigonus	crysoleucas	N	MG	T
Bridle shiner	Notropis	bifrenatus	N	MG	I
Spottail shiner	Notropis	hudsonius	N	MG	M
Fathead minnow	Pimephales	promelas	N	MG	T
E Blacknose dace	Rhinichthys	atratulus	N	FS	T
Longnose dace	Rhinichthys	cataractae	N	FS	M
Creek chub	Semotilus	atromaculatus	N	MG	T
Fallfish	Semotilus	corporalis	N	FS	M
Common carp	Cyprinus	carpio	I	MG	T
Catostomidae					
White sucker	Catostomus	commersoni	N	FD	T
Creek chubsucker	Erimyzon	oblongus	N	FS	I
Ictaluridae					
Yellow bullhead	Ameiurus	natalis	I	MG	T
Brown bullhead	Ameiurus	nebulosus	N	MG	T
White catfish	Ictalurus	catus	I	MG	M
Cyprinodontidae					
Banded killifish	Fundulus	diaphanus	N	MG	T
Moronidae					
White perch	Morone	americana	N	MG	M

APPENDIX B, continued

Expected Fishes of the Quinebaug River Basin

Common name	Genus	Specis	Introduced or Native	Habitat Use Classification	Pollution tolerance
Centrarchidae					
Rock bass	Ambloplites	rupestris	I	MG	M
Redbreast sunfish	Lepomis	auritus	N	MG	M
Pumpkinseed	Lepomis	gibbosus	N	MG	M
Bluegill	Lepomis	macrochirus	I	MG	T
Smallmouth bass	Micropterus	dolomieu	I	MG	M
Largemouth bass	Micropterus	salmoides	I	MG	M
Black crappie	Pomoxis	nigromaculatus	I	MG	M
Percidae					
Tesselated darter	Etheostoma	olmstedi	N	FS	M
Swamp darter	Etheostoma	fusiforme	N	MG	I
Yellow perch	Perca	flavescens	N	MG	M
Cottidae					
Slimy sculpin	Cottus	cognatus	N	FS	I

APPENDIX C

Application of Target Community to Smaller Streams

One recommendation not implemented in this target fish report was dividing the Quinebaug River into two sections: a warmwater lowland reach, and a coldwater upland reach. Many characteristics of the river differ between reaches above and below the steep section in Southbridge. We also found some early accounts (Massachusetts Division of Fisheries and Wildlife) of Quinebaug River that suggested the river upstream of Southbridge was a trout stream. We attempted to specify a target community for the upper Quinebaug River study reach (Brimfield Dam to Southbridge). This effort was abandoned because a target community for the upper river appeared to be the same as that presented in this report.

This appendix reports on our effort to specify a upper river target fish community. The Quinebaug River in the vicinity of Fiskdale has a channel about 20 meters wide on average. Robert Maietta, Massachusetts Department of Environmental Protection, provided us with fish community surveys on nine quality streams with average widths from 5 to 9 meters. The smallest appeared to be coldwater trout streams because brook trout were common or dominant. However, the largest of the streams had a fish community that was very similar to our Quinebaug River target community. The table below presents composition data for Muddy Brook (9.4 m wide, Ware MA) and Turkey Hill Brook (9.1 m wide, Spencer MA) and the Quinebaug River target community. Both streams had fish collections that matched the target community well (affinity values 63 and 74). Turkey Hill Brook had an affinity value considerably higher than any current sample site on the Quinebaug River. Both streams are in the Connecticut River basin and some modification of the target community specification should be done to adjust for Connecticut River basin fishes (e.g., redbreast sunfish). Nevertheless, these quality small streams were very similar to our target fish community. While much smaller than the Quinebaug River, these streams did not have coldwater fish in a high enough abundance to warrant a new taxa category or to displace the most abundant fishes listed in the table below. Our conclusion then is that there is not likely to be a substantial difference in a second target fish community specific to the upper study reach, and that the current target fish community is appropriate for the whole main Quinebaug River.

	Percent composition		
Taxa Category	**QR Target**	**Muddy Brk.**	**Turkey Hill Brk.**
Fallfish	31	43	54
Common Shiner	15	4	19
White Sucker	10	9	10
Longnose Dace	8	33	5
Blacknose Dace	6		6
Tesselated Darter	5	6	2
Redbreast Sunfish	3		
American Eel	3		
Yellow Perch	3		
Pumpkinseed	2	1	0
Other	14	4	4
Percent Affinity		**63**	**74**